South African Journal of Economic and Management Sciences
ISSN: (Online) 2222-3436, (Print) 1015-8812

Will a carbon-backed digital currency be adopted and used? A South African case study

Authors:
Wendy McCallum[1,2]
Euan Phimister[2]
Jako Volschenk[2]

Affiliations:
[1]Department of Economics and Economic History, Faculty of Commerce, Rhodes University, Makhanda, South Africa

[2]Stellenbosch Business School, Faculty of Economic and Management Sciences, Stellenbosch University, Stellenbosch, South Africa

Corresponding author:
Wendy McCallum,
wendy.mccallum@ru.ac.za

Dates:
Received: 21 Aug. 2025
Accepted: 29 Apr. 2026
Published: 30 May 2026

How to cite this article:
McCallum, W., Phimister, E. & Volschenk, J., 2026, 'Will a carbon-backed digital currency be adopted and used? A South African case study', *South African Journal of Economic and Management Sciences* 29(1), a6494. https://doi.org/10.4102/sajems.v29i1.6494

Background: Voluntary carbon markets represent an opportunity to increase the flow of finance to climate change mitigation measures, as espoused in the Paris Agreement, but remain modest in their capital mobilisation efforts.

Aim: The study aims to explore whether a private-sector-led carbon-backed digital currency will be adopted and used. Increased adoption will channel more capital to fund the estimated $7.4 trillion in annual climate finance required to achieve net zero by 2050.

Setting: A pilot carbon-backed digital currency was launched in South Africa in 2022, and the entrepreneurs provided trading data to the researchers.

Method: The pilot provided empirical evidence and impetus to explore the adoption and usage trends of this blockchain-based innovation through a case study methodology.

Results: The adoption of a carbon-backed digital currency, underpinned by intensive activation activities, shows promise. Usage is influenced by increased awareness and socialisation in the market. Merchants hold the currency as assets, and individuals take advantage of incentive opportunities.

Conclusion: Explicit incentivisation will increase adoption of a carbon-backed digital currency. An increase in price encourages adoption and use, and tax incentives to reduce capital gains can further increase adoption, and, thus, increase climate finance flows. However, decentralised digital currencies pose several financial stability concerns for regulators, and consumer protection is paramount.

Contribution: This study contributes to the emerging body of knowledge on the market mechanisms of digital currencies that yield positive environmental outcomes by exploring what drives adoption and use in an emerging market context.

Keywords: digital currency; FinTech; sustainable finance; voluntary carbon markets; technology adoption; blockchain technology.

Introduction

The exploration of an innovative financial instrument is necessary to determine whether it can achieve its aspirations to curb carbon dioxide emissions and slow the progression of climate change and its adverse impacts. Climate change, characterised by an increase in average annual temperatures resulting from rising carbon dioxide and other greenhouse gas emissions, poses unprecedented risks globally. There is broad agreement that climate change will adversely impact humanity (Handmer, Dover & Downing 1999; Hulme 2003; Kellogg 2019). Climate change heightens risks to health, food security, infrastructure in low-lying locations and economic productivity, and can exacerbate displacement and social inequalities.

Public sector interventions to internalise the price of carbon in production processes, such as carbon taxes and emission trading schemes, have had varying degrees of success (Pauw et al. 2020). Notwithstanding public sector interventions, carbon dioxide emissions have continued to increase.

The failure of public sector mechanisms to reduce carbon dioxide emissions necessitates investigating whether private sector interventions can augment governments' efforts to channel finance to carbon dioxide emissions-reducing activities.

A carbon-backed digital currency has been theorised as a solution to channel finance to activities that mitigate carbon dioxide emissions. Button (2008) questioned whether carbon could be considered a currency, and Liu, Chen and Xiao (2022) theorised a global carbon-backed digital

currency that fulfils the functions of money, that is, unit of account, medium of exchange and store of value.

Whilst this innovative solution has been conceptually explored, there is limited empirical evidence examining the practical implementation of a carbon-backed digital currency and whether it can contribute to reducing or removing carbon dioxide emissions.

The price of carbon-backed digital currency, as theorised by Liu et al. (2022), is determined by market mechanisms, that is, buying and selling the digital currency via an exchange platform. An increase in demand for the digital currency increases its price, determined by the laws of supply and demand. The proceeds from the sale of carbon are channelled to carbon dioxide-reducing and/or removing activities, with the ultimate goal of slowing climate change.

The theory of a carbon-backed digital currency is premised on the assumption that individuals and institutions will adopt and use the digital currency. Adoption, in the context of a carbon-backed digital currency model, can be considered a proxy for demand. The empirical exploration of the adoption (i.e. demand) of a carbon-backed digital currency is limited and requires further examination to confirm or contest this key assumption of the conceptual model.

Toco[1] was launched in South Africa in 2022 as a pilot to test the concept of a carbon-backed digital currency (McLeod 2023). Toco traded in South Africa from January to October 2023. Data from this pilot, provided by the entrepreneurs to the researchers, enable an initial exploration of whether and why prospective users will adopt and use the currency.

The main objective of this research is to examine the drivers of adoption and use of a carbon-backed digital currency. More specifically, the research seeks to examine the influence of price, circulation (as a proxy for social acceptance) and awareness-based and incentives-based marketing on adoption and use. Answers to these questions will indicate why a carbon-backed digital currency will be adopted and used, and can aid the design, operationalisation and scaling of an innovative digital financial instrument.

The research contributes to the nascent extant literature on carbon asset-referenced digital currencies and extends existing theorisation. Price and intensive activation activities are identified as drivers of adoption and use, based on the analysis of unique trading data.

Exploring the practical application of the theoretical model of a carbon-backed digital currency is important to determine whether this digital innovation is a feasible solution for channelling finance to slow climate change. Findings from the analysis of data generated during the 1-year pilot provide useful empirical insights to developers of carbon asset-referenced digital currencies, prospective individual and institutional users and policymakers.

1.'Toco' (capitalised) is the name of the trading platform (organisation) responsible for trading the digital currency 'toco' (non-capitalised) issued by The Carbon Reserve (akin to a central bank). This naming convention follows how the entrepreneurs refer to their entity (Toco) and digital currency (toco).

Conceptual framework

A carbon-backed digital currency market brings together two distinct markets: A voluntary carbon market and a digital currency market. The actors and characteristics of each market are briefly outlined as the context for the empirical exploration of toco trading data.

Voluntary carbon markets

A voluntary carbon market (VCM) facilitates the voluntary trading of carbon assets, including carbon credits linked to carbon offsets. Voluntary carbon markets are differentiated from regulated trading schemes such as emissions trading schemes (ETS), in which targets determine trading and personal carbon trading schemes.

The recognition of VCMs was formalised in the Conference of the Parties (COP) agreements. Article 6 of the Paris Agreement, signed in 2015, provides for trading carbon credits as a mechanism for signatory countries to meet their Nationally Determined Contributions (United Nations n.d.). This, coupled with the 'rules of the game' for carbon credit trading and accounting finalised at COP26 in Glasgow in 2021 (The Conversation 2021) and the establishment of carbon markets standards and a Supervisory Body at COP29 in Baku in 2024 (United Nations 2024), gives greater credence to voluntary carbon markets as a mechanism to trade carbon credits.

Buyers purchase carbon credits to offset their carbon emissions. Buyers will buy carbon credits from sellers, such as carbon credit providers, traders, brokers or carbon exchanges (including ETSs). Traders and brokers typically purchase carbon credits from carbon credit providers. Carbon credit providers channel financial capital received from buyers, traders and brokers into carbon emission reduction, removal or avoidance projects in specific localities (countries). The carbon emission reduction, removal or avoidance of projects is independently verified by organisations responsible for determining and verifying carbon credit standards, for example, the gold standard, or Verra, which administers the Verified Carbon Standard (VCS), over a project's lifetime. Financial inflows to projects from the sale of carbon credits are accounted for as revenue and used to fund operations and/or repay debt provided by project funders (Verra 2025).

Key challenges in VCMs are: (1) the quality of carbon credits, in other words, will the project reduce, avoid or remove tonnes of carbon that it claims to within given timeframes; (2) transparency of measurement, reporting and verification (MRV) of carbon dioxide emissions; and (3) the transaction costs involved in trading, MRV to confirm credibility of projects' carbon emissions claims, and providing intermediation services to match sellers with buyers (Donofrio et al. 2021; Janiaud 2023).

On the supply side, verification of carbon credits is typically conducted every 3 to 4 years and is costly. Blockchain technologies and other digital innovations can support MRV and provide digital platforms for intermediation, reducing transaction and intermediation costs. But there remains the challenge of quality of carbon credits and use of proceeds.

On the demand side, willingness to purchase carbon credits is influenced by economic incentives (Tan, Wang & Zaidi 2019) and social influence, beliefs and behaviours according to Sterns' (2000) Attitude-Behaviour-Context (ABC) theory and supported by empirical evidence (Frey & Stutzer 2008; Tao, Duan & Zeng 2021). The growing pressures on firms in developed countries, both regulatory and public, are likely to increase demand for carbon credits. Recent experience, however, suggests that this is unlikely to meet the scale of the climate change challenge (Ecosystem Marketplace 2023).

Digital currency markets

A digital currency is a currency that exists only in electronic form. It is issued digitally and is traded and/or used as a means of payment using digital channels (Ammous 2018). Digital currencies are secured using cryptography and stored on a distributed ledger, such as a blockchain. Blockchain technology enables cryptographic encoding and decoding of digital assets through a distributed system of verification and governance (Zheng & Lu 2022).

Key examples of digital currencies include cryptocurrencies, typically governed by a decentralised governance system; stablecoins, which are pegged to a fiat currency; and Central Bank Digital Currency (CBDC), typically issued by a central bank and intended to have the same functionality as a fiat currency (Fatás 2019).

In a decentralised governance system, a decentralised autonomous organisation (DAO) is typically formed by the developers of a digital currency. The DAO issues a governance directive (termed a white paper) that explains how the digital currency will be managed (issuance, verification, voting rights of members, etc.). A DAO includes validators who verify digital currency transactions by decoding cryptographic keys.

The advantages of digital currency markets include increased transparency, reduced transaction costs and greater security and traceability of digital assets (Lewis, McPartland & Ranjan 2019; Pal, Tiwari & Behl 2021). The features of digital currencies are well-suited to respond to the challenges of VCMs (Woo et al. 2021). However, there are disadvantages to digital currency markets, including price volatility and regulatory uncertainty (Baur & Dimpfl 2021; Van der Linden & Shirazi 2023).

The adoption of digital currencies by users (individuals and organisations) is influenced by the benefits users perceive a digital currency will deliver relative to fiat currency, and how easy it will be to use the digital currency, according to the Technology Adoption Model (TAM) (Davis 1989). The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003) extends the TAM by adding social influence and facilitating conditions (e.g. organisational and technological factors). Theory and empirical evidence concur that adoption is most significantly influenced by perceived benefits and is moderated by age, gender and prior technology experience (Davis 1989; Ma et al. 2022; Soilen & Benhayoun 2021; Venkatesh et al. 2003).

Carbon-backed digital currency

Like all forms of money, digital currencies can act as a store of value, a unit of account and a medium of exchange. Whilst the role driving the adoption of many digital currencies, for example, Bitcoin, appears to have been primarily as a store of value, the potential for using a currency to increase demand for carbon credits arises from its use as a medium of exchange in addition to its potential as a store of value, as theorised by Liu et al. (2022).

At the simplest level, imagine a country adopting an exclusive digital currency where a unit of carbon credits backs every dollar in circulation. By definition, the value of transactions in the economy in any period (the price level times output quantity) equals the money in circulation times its velocity (the number of times it changes hands per period). Hence, in the case of a carbon-backed currency, if the monetary authorities increase the money supply, for example, by an extra dollar, the monetary authority increases its holdings by an extra carbon credit. If the velocity of money is assumed to be relatively constant over time, this generates a significant increase in the demand for carbon credits from the demand for currency for transactions. As in the original gold standard, a fully commodity-backed currency poses risks for overall monetary stability (Bernanke 1993), which, from a central bank perspective, are likely to outweigh any benefits associated with increasing the demand for carbon.

However, a voluntarily adopted carbon-backed digital currency, such as toco, used primarily as a medium of exchange, can also significantly increase demand for the underlying carbon assets. However, the sustainable level will depend on the structure of transactions demanded by consumers and merchants. For example, assume 1000 individuals in a community voluntarily use a carbon-backed digital currency to purchase the coffee they drink weekly. Assume each individual drinks one cup of $2.00 coffee daily, and the toco to dollar exchange rate is 0.25 toco per dollar. If each individual buys their toco at the beginning of the week, then there will be 3500 toco in circulation at the beginning of each week. Coffee merchants in the community are assumed to accept toco as payment for coffee, but only exchange the toco they hold with the central carbon exchange agency at the end of the week for dollars. Then it follows that on any day of the week, there are 3500 toco in circulation. Initially, the consumers hold all the toco, but then progressively through the week, merchants will hold more. At the end of the week, merchants exchange their toco for dollars, but this is matched by consumer demand for the toco required for next week's purchases, assuming transaction costs are zero to simplify the argument.

The confluence of TAM, UTAUT and ABC theories asserts that behavioural intent influences the adoption of digital currencies and carbon credits. Behavioural intent is influenced by perceived benefits, ease of use, network effects (social influence) and organisational and technical factors. Thus, it is expected that the price of toco, expressed as the exchange rate between Rands and toco, intensive marketing and network effects will increase adoption and use. Whilst a carbon-backed digital currency has been theorised, and carbon credit and digital currency adoption have been separately theorised and studied empirically, an empirical assessment of the factors that influence the adoption of a carbon-backed digital currency remains a gap in the literature.

Methods

The primary purpose of this research was to empirically investigate factors influencing the adoption and use of carbon-backed digital currency and to examine whether there is a relationship between adoption, use, price, marketing activities and network effects.

A descriptive narrative and graphical representation of key data made available by the entrepreneurs are presented as the structural context for examining adoption and use.

Anonymised toco registration and transaction data, the carbon asset registry, changes in the exchange rate between toco and Rands, and the date and nature of activation events for the period January to October 2023 were provided to the researchers. Monthly wallet registration data are used as a proxy for adoption, and daily trading data for merchants and individuals are used as a proxy for usage.

Regression analysis of registration and trading data was used to corroborate or challenge the theoretical and empirical foundations of VCMs and digital currency markets relative to the toco case, and to explore whether new knowledge exists to advance the theory.

Price (i.e. buy exchange rate) (exc_buy), number of toco in circulation (circ) representing network effects, activation events to raise awareness (act_aware) and activation events offering incentives (act_incen) are used as explanatory variables to estimate their influence on adoption (i.e. wallet registrations) (wall). The sample size is small (n = 9), as only monthly wallet registration data for the period March to November 2023 was provided to the researcher. Thus, adoption is estimated using a log-linear specification in Equation 1:

$$log(wall_t) = \alpha + \beta_1 exc_{buy_t} + \beta_2 circ_t + \beta_3 act_{aware_t} + \beta_4 act_{incen_t} + \varepsilon_t \quad \text{[Eqn 1]}$$

The initial estimation was constrained in its explanation of adoption, largely owing to limited observations, and identified only one explanatory variable (act_aware) as significant. Thus, a parsimonious model was re-specified, prioritising parameter estimation for a key explanatory variable. The model is re-specified in Equation 2:

$$log(wall_t) = \alpha + \beta\, act_{aware_t} + \varepsilon_t \quad \text{[Eqn 2]}$$

Adoption models were estimated using ordinary least squares with Huber–White robust standard errors to account for heteroskedasticity detected using the Breusch–Pagan test.

Price (i.e. exchange rate) (exc_buy and exc_sell), the number of toco in circulation (circ) as a proxy for network effects, and activation events to raise awareness (act_aware) and to offer incentives (act_incen) are used as explanatory variables to estimate their influence on usage. Usage is disaggregated into daily buying and selling transactions for merchants and individuals represented as mer_buy, mer_sell, ind_buy and ind_sell, respectively. The sample size is 219 over the period 28 March to 07 November 2023.

The model is estimated using dynamic first differencing to determine the short-run effect of marginal changes in the independent variables on marginal changes in the dependent variables, to correct for autocorrelation detected using the Breusch–Godfrey LM test and to ensure stationarity. A dynamic lagged first difference of the dependent variable is included to examine short-run mean-reversion behavioural tendencies. Activation activities are estimated as discrete interventions to capture the effect of marketing activities on usage. Usage for merchants buying toco, merchants selling toco, individuals buying toco, and individuals selling toco was estimated using Equation 3 to Equation 6, respectively:

$$\Delta mer_{buy_t} = \alpha + \rho \Delta mer_{buy_{t-1}} + \beta_1 \Delta exc_{buy_t} + \beta_2 \Delta circ + \gamma_1 act_{incen_t} + \gamma_2 act_{aware_t} + \varepsilon_t \quad \text{[Eqn 3]}$$

$$\Delta mer_{sell_t} = \alpha + \rho \Delta mer_{sell_{t-1}} + \beta_1 \Delta exc_{sell_t} + \beta_2 \Delta circ + \gamma_1 act_{incen_t} + \gamma_2 act_{aware_t} + \varepsilon_t \quad \text{[Eqn 4]}$$

$$\Delta ind_{buy_t} = \alpha + \rho \Delta ind_{buy_{t-1}} + \beta_1 \Delta exc_{buy_t} + \beta_2 \Delta circ + \gamma_1 act_{incen_t} + \gamma_2 act_{aware_t} + \varepsilon_t \quad \text{[Eqn 5]}$$

$$\Delta ind_{sell_t} = \alpha + \rho \Delta ind_{sell_{t-1}} + \beta_1 \Delta exc_{sell_t} + \beta_2 \Delta circ + \gamma_1 act_{incen_t} + \gamma_2 act_{aware_t} + \varepsilon_t \quad \text{[Eqn 6]}$$

All usage models were estimated using ordinary least squares with Huber–White robust standard errors to account for heteroskedasticity detected in selling models using the Breusch–Pagan test.

Ethical considerations

Ethical clearance to conduct this study was obtained from the Stellenbosch University Social, Behavioural and Education Research Ethics Committee (SBER) (No. 29152).

Results

Structure of the toco market

Toco was a private sector-led platform facilitating participation in a voluntary carbon market premised on a

carbon-backed digital currency. Toco aimed to respond to the challenges of increasing carbon emissions by creating a market to buy, sell and make payments using a carbon-backed digital currency and channelling the proceeds of sales of the carbon-backed digital currency to carbon reduction or removal activities. Proceeds of sales are channelled directly by financing projects or indirectly by buying existing carbon credits (World Economic Forum n.d.). Toco can be considered innovative because it is a 'new combination' of resources, processes and products and/or services, as Schumpeter (1934) defines innovation in the economy. The Toco team comprised entrepreneurs with extensive experience in financial services and digital (McLeod 2023).

Actors in the toco market include the Carbon Reserve (similar to a central bank), projects and carbon market exchanges, Toco (digital interface for users to trade toco), individual users and merchants (companies) (The Hub n.d.). The interactions between actors in the toco market and the flows of carbon assets, fiat currency and digital currency (toco) are summarised in Figure 1 and briefly described.

The Carbon Reserve is an independent entity responsible for the governance of a digital currency (toco) backed by carbon credits as the underlying asset. Its functions can be likened to a central bank responsible for money supply and monetary policy. One unit of the digital currency, called toco, equates to one risk-adjusted tonne of carbon reduction, removal or avoidance. The Carbon Reserve purchased carbon credits from traders and project developers. The Carbon Reserve has developed a risk-adjustment weighting policy for carbon assets based on the quality of the investment or carbon credits purchased, and the Board of Governors applies the risk-adjustment policy (World Economic Forum n.d.). For example, if a carbon credit is risk-weighted 100%, then one tonne of carbon emission reduction for that carbon credit equates to one digital currency that can be minted. If a carbon credit is risk-weighted 50%, then two tonnes of carbon emission reduction for that carbon credit equates to one unit of digital currency that can be minted. All information about the underlying asset, that is, the carbon credit, was stored by the Carbon Reserve on a registry using blockchain technology and was available for scrutiny by buyers and sellers of toco (The Hub n.d.).

The Carbon Reserve's Monetary Committee decides on the quantity of digital currency to be issued. Carbon assets back all the digital currency issued, and the Carbon Reserve practised prudence; in that it held more carbon credits than it issued digital currency. According to data shared by the entrepreneurs, as of the end of October 2023, the Carbon Reserve held 6883 risk-adjusted carbon assets; 78% were AA-rated assets, and 22% were BBB-rated assets. The Carbon Reserve minted 2000 toco in 2022, backed by risk-adjusted carbon assets. 1980 of the 2000 toco minted were transferred to the Toco platform's wallet for trading.

Toco manages the supply of toco following the traditional theory of monetary policy expressed as MV = PQ, where M is the money supply, V is the money velocity, P is the price of goods and services, and Q is the quantity of goods and services produced. When considering the price and quantity of carbon assets in carbon markets, PQ is substituted by Equation 7:

$$\frac{P\left(\Delta C_{atm} + \kappa\delta\right)}{\varepsilon} \quad \text{[Eqn 7]}$$

Where P is the price of carbon assets, that is, the price of a carbon asset relative to fiat currency (in this case, the South African rand), ΔC_{atm} is the change in atmospheric carbon content, δ is the carbon mitigation price supply with elasticity κ and ε is the average human emission footprint per capita production of goods and services.

The Toco platform is a toco broker and exchange that uses a digital application programming interface for users of

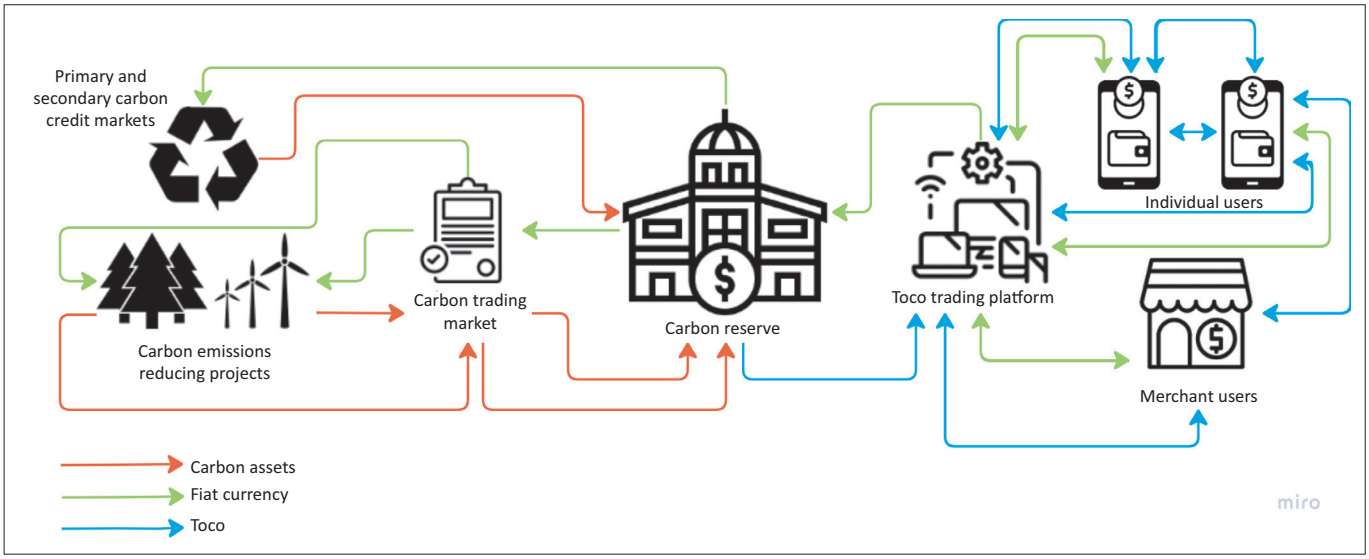


FIGURE 1: Representation of toco market.

toco to buy, sell and transact using toco. Individuals or companies can register an e-wallet using the Toco application. This involves providing some basic personal information used for verification and due diligence of the user (i.e. Know Your Customer) as a compliance mechanism. Users who did not provide sufficient information for Know Your Customer (KYC) could transact with toco on the platform up to a $265.00 equivalent cap, using the exchange between United States Dollars (USD) and South African Rands (ZAR) on 04 April 2024.

The toco case is similar to a voluntary carbon market; in that it is voluntary for users to purchase toco, and purchasers and recipients of toco can sell toco for fiat currency at any time. The Toco platform commenced trading in November 2022 and ceased trading in South Africa in November 2023 because of cross-border regulatory issues (Economist Impact Events 2024).

Users could buy and sell toco on the Toco platform and can pay or send toco to other registered users. Users are categorised as individual users and merchants, that is, companies that accept toco as a means of payment. Users could send toco to other users using a quick response (QR) code generated by the Toco application.

The Toco platform charges a transaction fee for every transaction. The fees are a 1% transaction fee for senders on all transactions, and the greater of R15 or 1% of the toco sold when toco are sold back to the Toco platform. A unique selling point of toco as a merchant payment mechanism is that the transaction costs are lower than those of major payment competitors like Visa or Mastercard.

Users buy toco with fiat currency, in this case, South African Rands. The Carbon Reserve determines the exchange rate between toco and the fiat currency and can change the price of a toco. Changes in the exchange rate are influenced by the price of carbon credits to which tocos are pegged. The Carbon Reserve published changes to the exchange rate on the Toco website, which are summarised in Table 1. The exchange rate was published in South African Rands (ZAR). The exchange rate between toco and USD is calculated and presented for comparative purposes.

For comparative purposes, one carbon asset traded on the European Union (EU) ETS was traded at about 84 euros at the beginning of January 2023 and about 88 euros in August 2023. The price point of toco, coupled with an easy-to-use digital platform, democratises trading of carbon credits for individuals, and it is perhaps this feature of the concept that is most innovative. Typically, corporate companies trade in carbon credits, and broadening access to individuals to trade in carbon credits opens up access to more (personal) finance that can be allocated to carbon emissions reduction.

TABLE 1: South African Rands/toco and United States Dollars/toco exchange rate (November 2022–August 2023).

Date	Buy rate (ZAR/toco)	Buy rate (USD/toco)	Sell rate (ZAR/toco)	Sell rate (USD/toco)
11 November 2022	203.6	11.78	206.7	11.96
15 December 2022	192.1	11.07	195.0	11.24
07 June 2023	177.3	9.26	180.0	9.40
10 August 2023	178.2	9.48	180.0	9.58

Note: Based on Toco data provided by entrepreneurs and South African Reserve Bank, 2024, viewed 12 December 2024, from https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics/selected-historical-rates.

ZAR, South African Rands; USD, United States Dollars.

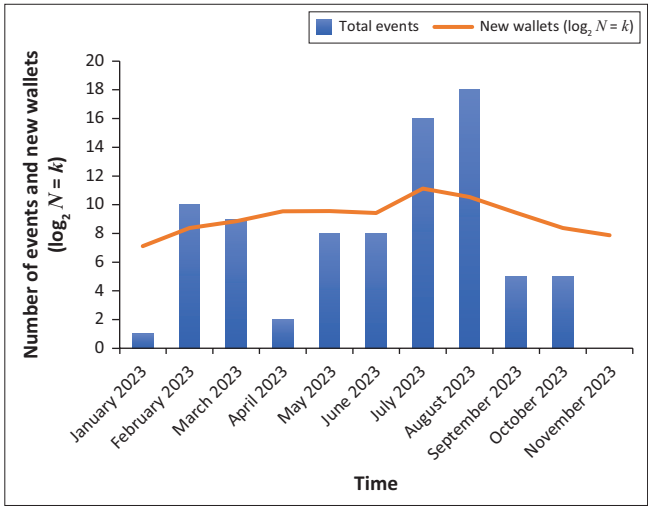
It is useful to explore whether there is any apparent relationship between changes in the exchange rate and the adoption and usage behaviour of individual and merchant users. In general equilibrium theory, changes in the exchange rate (price) of traded assets will increase demand for the asset if the relative price of the asset increases.

Adoption and usage

Adoption: A total of 8260 individual users and 218 merchants were registered between November 2022 and October 2023. Figure 2 suggests a correlation between the number of registered individual users and activation activities, prompting further investigation using regression analysis.

Scheduled activation activities comprised events, for example, social events hosted in partnership with sustainable fashion merchants, information sessions, for example, talks at university societies and incentives, for example, faster access to social facilities. Registration of merchants was primarily related to one-to-one conversations between the Toco Chief Executive Officer (CEO) and a merchant representative. Merchants were predominantly smaller independent merchants located in Stellenbosch.

Activation activities to encourage registration of individual users targeted Stellenbosch University students. An estimated 32 000 students were registered at Stellenbosch in 2023 (Stellenbosch University n.d.). Assuming that the majority (90%) of registered individual users are university students, it is estimated that market penetration from



Note: Based on analysis of Toco data provided by entrepreneurs.

FIGURE 2: Activation events and new wallet registrations (January 2023 – November 2023).

November 2022 to October 2023 was approximately 23%. In comparison, user adoption of other digital currencies was estimated at 10% to 14% in 2023 (Ozili & Alonso 2024).

The results of an initial fully specified adoption model, presented in Table 2, indicate that only activation activities to increase awareness of toco are positive and statistically significant (10% confidence level). Thus, adoption is neither related to price nor to incentives, but rather to reduced information asymmetry.

The results of the parsimonious model, which estimates the effect of only activation activities associated with awareness and are presented in Table 3, indicate that one additional activation event will result in a 10% increase in wallet registrations.

Intensive marketing is required to increase the adoption of a novel digital currency. This is unsurprising, as a carbon-backed digital currency needs to be introduced, its association with carbon credits understood, and its expected benefits socialised in the market. Whilst not explicitly identified in the TAM or UTAUT, organisational support is a facilitating condition, and marketing could be considered an organisational intervention to support the adoption of a new digital currency.

The results of the model indicate that adoption of a carbon-backed digital currency is dependent on reducing information asymmetry. This is in contrast to existing theoretical models of technology adoption, such as the TAM and UTAUT, that suggest that economic incentives are the most notable driver of adoption and use.

Usage: Toco categorised users into three categories: Registered users, active users and habitual users. Registered users are those who have registered but have not completed KYC requirements. This comprises about 60% of users, as illustrated in Figure 3. Active users are those who have registered, completed KYC requirements, and have concluded at least one transaction on the platform within a 30-day period. Habitual users are those who have registered and concluded more than one transaction within a 30-day period. These comprise the lowest proportion of users (3%). Inactive users are those who have registered and completed the KYC requirements but have not transacted, in other words, bought or sold one or more toco. The conversion from registered to active to habitual users is an important development that would require more targeted interventions beyond activation activities that encouraged registration.

The majority of transactions between January and October 2023 were toco transfers, as shown in Figure 4. Transfers include C2C (customer-to-customer), B2B (business-to-business) and C2B (customer-to-business). The latter two transfers are payments for goods and services and comprise the majority of transactions.

The results of models estimating merchants' and individuals' toco buying and selling behaviour are presented in Table 4.

There is evidence that merchant buying and selling, and individual buying and selling behaviour, are mean-reverting

TABLE 2: Initial fully specified adoption model.

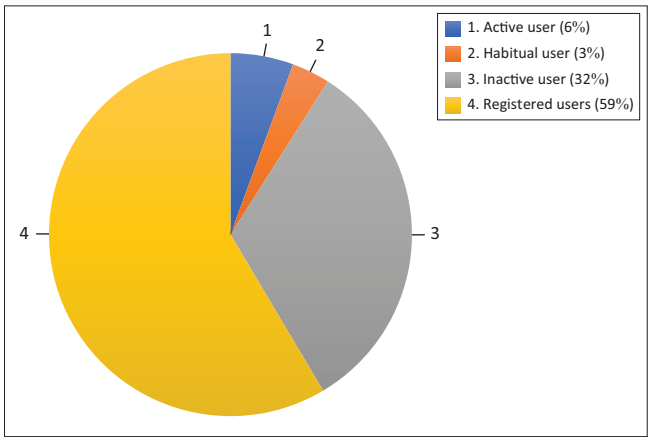
Variable	Coefficient	Robust standard error	*p*-value
Exchange rate (buy)	-0.050	0.068	0.508
Circulation	0.001	0.002	0.671
Activation (incentives)	-0.001	0.018	0.955
Activation (awareness)	0.106*	0.040	0.059
Constant	14.068	10.402	0.248

Note: $n = 9$; $R^2 = 0.693$.
***, 1% confidence level; **, 5% confidence level; *, 10% confidence level.

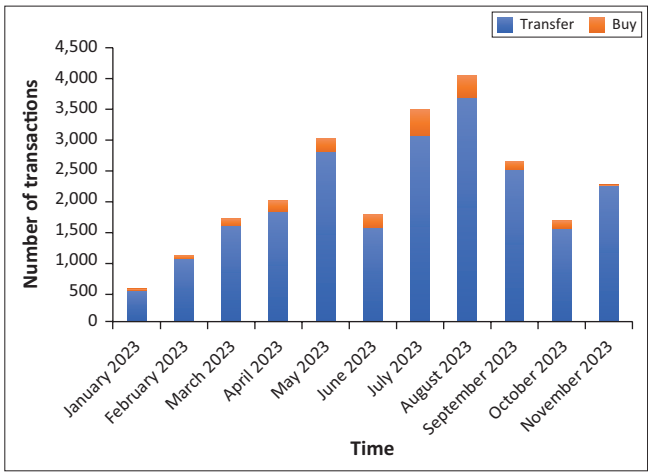
TABLE 3: Parsimonious adoption model.

Variable	Coefficient	Robust standard error	*p*-value
Activation (awareness)	0.104**	0.036	0.022
Constant	5.933***	0.298	0.000

Note: $n = 9$; $R^2 = 0.693$. Heteroskedasticity was tested using the Breusch–Pagan test ($p = 0.54$) indicating that homoskedasticity is present.
***, 1% confidence level; **, 5% confidence level; *, 10% confidence level.
Heteroskedasticity was tested using the Breusch–Pagan test ($p = 0.54$) indicating that homoskedasticity is present.



Note: Based on analysis of Toco data provided by entrepreneurs.
FIGURE 3: Individual user by type.



Note: Based on analysis of Toco data provided by entrepreneurs.
FIGURE 4: Transaction by type.

TABLE 4: Heteroskedasticity-robust usage models.

Variable	Merchant buy		Merchant sell		Individual buy		Individual sell	
	Coefficient	Robust standard error	Coefficient	Robust standard error	Coefficient	Robust standard error	Coefficient	Robust standard error
Lagged first difference	-0.497*	0.297	-0.471***	0.109	-0.417**	0.170	-0.492**	0.197
Exchange rate	0.038	0.044	-0.892	2.087	0.411	1.753	-0.136	1.334
Circulation	-0.001	0.001	-0.068	0.043	0.163	0.220	-0.574***	0.163
Incentive	-0.401	1.266	12.719	24.583	14.536	34.462	21.715*	11.952
Activation (awareness)	-1.303	1.566	-24.827**	10.237	-12.133	11.820	-0.734	11.595
R^2	0.251	-	0.273	-	0.179	-	0.482	-

Note: n = 219. Heteroskedasticity was tested using the Breusch-Pagan test (merchant buy: p = 0.8458; merchant sell: p = 0.0147; individual buy: p = 0.0795; individual sell: p = 0.000). Therefore, all models are estimated using heteroskedasticity-robust standard errors.

***, 1% confidence level; **, 5% confidence level; *, 10% confidence level.

in the short run, indicating that the propensity for merchants and individuals to buy toco is negatively related to toco purchased in preceding trading days. This possibly reflects underdeveloped use cases for the digital currency and a resulting preference not to hold too many toco.

Merchant buying behaviour is not influenced by price, network effects (circulation) and activation activities. Awareness activations reduce selling by merchants, underscoring the importance of reducing information asymmetry about the benefits of holding toco for merchants, for example, potential future price increases (i.e. holding toco as an asset), and environmental, social, and governance (ESG) considerations.

Individual buying behaviour is not influenced by price, network effects (circulation) and activation activities. Network effects and incentives are statistically significant influencers of individual selling behaviour. The negative relationship between circulation and selling toco is indicative of network effects: As more toco in circulation are adopted by users, fewer individuals want to sell toco. Incentives can induce individuals not to sell toco, for example, rewards for not exchanging toco for Rands for a specified period.

Thus, it may be concluded that usage is shaped by behavioural dynamics than by economic incentives, although economic incentives do influence individuals' selling behaviour, and reducing information asymmetry encourages merchants to hold toco. The effect of incentives on individual behaviour supports existing theoretical models and empirical evidence of adoption and use. Toco was operationalised in Stellenbosch, and it is reasonable to assume that the data used in this research are limited to users in Stellenbosch, which is not a typical representation of South African society or of emerging markets more broadly. Thus, findings may not be generalisable, and a broader study of a cross-section of South African society would strengthen generalisability across emerging market contexts.

Recommendations

Intensive activation activities to increase awareness of a new digital currency and explicit incentivisation are necessary to scale adoption and use of a carbon-backed digital currency, as the magnitude of finance that can be channelled to carbon emission reduction activities will increase only as adoption and use increase. The presence of network effects supports the need for initial intensive activation to increase adoption. Developers of similar digital currencies should dedicate financial and human resources to intensive marketing and socialisation of the digital currency in prospective markets. The costs associated with active, intensive marketing activities must be considered when assessing financial feasibility, especially for new digital financial instruments that are unknown in the market. Effective incentives that encourage users to buy and hold the digital currency must be established and offered. Regulators can incentivise adoption by recognising a carbon-backed digital currency as a crypto asset and offering tax incentives to encourage adoption and increase climate finance.

Further research into this innovative solution should focus on exploring the behavioural factors that influence the adoption of a carbon-backed digital currency, as findings from limited empirical data indicate that behavioural factors beyond economic incentives explain adoption. Additional avenues for research include exploring regulatory perceptions of a carbon-backed digital currency, simulating the market to investigate the effect of adoption of a carbon-backed digital currency by individual users on merchant adoption and vice versa, and modelling the effects of changes to the market, such as economic growth or changes in exchange rates of a digital currency and fiat currency.

Whether toco is a currency and whether carbon assets are defined as a commodity or asset will have implications for the operations and regulation of a carbon-backed digital currency. Thus, there is a need to explore if carbon is considered a traditional financial asset by regulators. Future studies can explore regulatory perspectives, as the introduction of regulation in a carbon-backed digital currency market will affect the demand and price of carbon-backed digital currencies, ultimately influencing the magnitude of climate finance.

Conclusion

The launch of toco in South Africa provided a unique opportunity to explore the structure of a carbon-backed digital currency market and test some of the assumptions of theorised models of adoption and usage.

Empirical evidence suggests that the adoption of a carbon-backed digital currency is influenced by intensive activation activities that raise awareness of the digital currency and its potential benefits. Merchant usage is influenced by increasing awareness of the perceived usefulness of the digital currency, whilst individual usage is influenced by other individuals' usage behaviour. Merchants and individuals exhibit behavioural tendencies to adopt and use the digital currency beyond economic incentives, challenging existing theories of adoption and use that find that financial benefit is the greatest predictor of behavioural intention. Why and for what purpose users are willing to adopt a carbon-backed digital currency (e.g. as a means of payment or as a financial asset) remains to be explored.

The findings of this research are limited, largely because of the constraints imposed by the data provided by the entrepreneurs. Monthly wallet registrations were provided, thereby limiting the potential to examine the relationship between activation events on specific days and wallet registrations and the number of observations available for regression analysis.

There is a need to test if carbon credits are considered a traditional financial asset by regulators; and if a carbon-backed digital currency, as a means to increase finance to reduce carbon emissions, will change how regulators consider and regulate a carbon-backed digital currency.

Notwithstanding the considerations and limitations of this research, toco, as an example of a carbon-backed digital currency, shows promise as a potential solution to channel finance to reduce carbon emissions. A more rigorous examination of feasibility can confirm its potential to increase climate finance.

Acknowledgements

Toco provided the inspiration and empirical context for this research. The authors acknowledge Toco's provision of de-identified data, which enabled this independent study of a novel digital financial innovation.

Competing interests

The authors, Wendy McCallum, Euan Phimister, and Jako Volschenk, declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

CRediT authorship contribution

Wendy McCallum: Conceptualisation, Formal analysis, Investigation, Methodology, Project administration, Software, Visualisation, Writing – original draft. Euan Phimister: Conceptualisation, Project administration, Supervision, Writing – review & editing. Jako Volschenk: Conceptualisation, Supervision, Writing – review & editing. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication and take responsibility for the integrity of its findings.

Funding information

The authors received no financial support for the research, authorship and/or publication of this article.

Data availability

The data that supports the findings of this study are not publicly available. The data that supports the findings of this study were shared with the authors for the purpose of research, and it was agreed that the authors would not share the data.

Disclaimer

The views and opinions expressed in this article are those of the authors and are the product of professional research. They do not necessarily reflect the official policy or position of any affiliated institution, funder, agency, or that of the publisher. The authors are responsible for this article's results, findings, and content.

References

Ammous, S., 2018, 'Can cryptocurrencies fulfil the functions of money?', *Quarterly Review of Economics and Finance* 70, 38–51. https://doi.org/10.1016/j.qref.2018.05.010

Baur, D.G. & Dimpfl, T., 2021, 'The volatility of Bitcoin and its role as a medium of exchange and a store of value', *Empirical Economics* 61, 2663–2683. https://doi.org/10.1007/s00181-020-01990-5

Bernanke, B.S., 1993, 'The world on a cross of gold: A review of 'Golden fetters: The gold standard and the great depression, 1919–1939'', *Journal of Monetary Economics* 31(2), 251–267. https://doi.org/10.1016/0304-3932(93)90047-J

Button, J., 2008, 'Carbon: Commodity or currency? The case for an international carbon market based on the currency model', *Harvard Environmental Law Review* 32, 571–596, viewed 12 April 2024, from https://journals.law.harvard.edu/elr/wp-content/uploads/sites/79/2019/07/32.2-Button.pdf.

Davis, F.D., 1989, 'Perceived usefulness, perceived ease of use, and user acceptance of information technology', *MIS Quarterly* 13(3), 319–340. https://doi.org/10.2307/249008

Donofrio, S., Maguire, P., Myers, K., Daley, C. & Lin, K., 2021, 'State of the voluntary carbon markets 2021', *Forest Trends*, viewed 12 April 2024, from https://www.forest-trends.org/publications/state-of-the-voluntary-carbon-markets-2021/.

Economist Impact Events, 2024, *Presentation: Turning carbon into money – Reviewing a new financial system*, viewed 12 April 2024, from https://www.youtube.com/watch?v=z2caa60v0OI.

Ecosystem Marketplace, 2023, 'All in on climate: The role of carbon credits in corporate climate strategies', *Forest Trends Initiative*, viewed 12 April 2024, from https://www.ecosystemmarketplace.com/publications/state-of-the-voluntary-carbon-market-report-2023/.

Fatás, A., 2019, *The economics of fintech and digital currencies*, Centre for Economic Policy Research Press, London.

Frey, B.S. & Stutzer, A., 2008, 'Environmental morale and motivation', in A. Lewis (ed.), *The Cambridge handbook of psychology and economic behaviour*, pp. 406–428, Cambridge University Press, Cambridge.

Handmer, J.W., Dovers, S. & Downing, T.E., 1999, 'Societal vulnerability to climate change and variability', *Mitigation and Adaptation Strategies for Global Change* 4, 267–281. https://doi.org/10.1023/A:1009611621048

Hulme, M., 2003, 'Abrupt climate change: Can society cope?', *Philosophical Transactions: Mathematical, Physical and Engineering Sciences* 361(1810), 2001–2021. https://doi.org/10.1098/rsta.2003.1239

Janiaud, A., 2023, 'South pole exits troubled Kariba carbon project over quality concerns', *Sustainability Views*, viewed 12 April 2024, from https://www.sustainableviews.com/south-pole-exits-troubled-kariba-carbon-project-over-quality-concerns/.

Kellogg, W.W., 2019, *Climate change and society*, Routledge, New York.

Lewis, R., McPartland, J. & Ranjan, R., 2019, 'Blockchain and financial market innovation', Global Commodities Applied Research Digest. J.P. Morgan Center for Commodities, University of Colorado Denver Business School, viewed 12 April 2024, from https://jpmcc-gcard.com/wp-content/uploads/2019/03/GCARD-Summer-2019-Chicago-Fed.pdf.

Liu, Q., Chen, Z. & Xiao, S.X., 2022, 'A theory of carbon currency', *Fundamental Research* 2(3), 375–383. https://doi.org/10.1016/j.fmre.2022.02.007

Ma, C., Jin, Z., Mei, Z., Zhou, F., She, X., Huang, J. et al., 2022, 'Internet of things background: An empirical study on the payment intention of central bank digital currency design', *Mobile Information Systems* 22, 4846372. https://doi.org/10.1155/2022/4846372

McLeod, D., 2023, 'Vumatel founders behind launch of toco, a new digital currency', *TechCentral*, viewed 09 December 2024, from https://techcentral.co.za/vumatel-founders-behind-launch-of-toco-a-new-digital-currency/222412/.

Ozili, P.K. & Alonso, S.L.N., 2024, 'Central bank digital currency adoption challenges, solutions and a sentiment analysis', *Journal of Central Banking Theory and Practice* 13(1), 133–165. https://doi.org/10.2478/jcbtp-2024-0007

Pal, A., Tiwari, C.K. & Behl, A., 2021, 'Blockchain technology in financial services: A comprehensive review of the literature', *Journal of Global Operations and Strategic Sourcing* 14(1), 61–80. https://doi.org/10.1108/jgoss-07-2020-0039

Pauw, W.P., Castro, P., Pickering, J. & Bhasin, S., 2020, 'Conditional nationally determined contributions in the Paris Agreement: Foothold for equity or Achilles heel?', *Climate Policy* 20(4), 468–484. https://doi.org/10.1080/14693062.2019.1635874

Schumpeter, P., 1934, *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle*, Transaction Publishers, New Brunswick.

Soilen, K.S. & Benhayoun, L., 2021, 'Household acceptance of central bank digital currency: The role of institutional trust', *International Journal of Bank Marketing* 40(1), 172–196. https://doi.org/10.1108/IJBM-04-2021-0156

South African Reserve Bank, 2024, *Selected historical rates: Rand per US dollar series, data repository*, viewed 12 December 2024, from https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics/selected-historical-rates.

Stellenbosch University, 2025, *Stellenbosch University is growing rapidly, as is its economic impact*, viewed 12 April 2024, from https://www.su.ac.za/en/node/19987.

Stern, P.C., 2000, 'Toward a coherent theory of environmentally significant behavior', *Journal of Social Issues* 56(3), 407–424. https://doi.org/10.1111/0022-4537.00175

Tan, X., Wang, X. & Zaidi, S.H.A., 2019, 'What drives public willingness to participate in the voluntary personal carbon-trading scheme? A case study of Guangzhou Pilot, China', *Ecological Economics* 165, 106389. https://doi.org/10.1016/j.ecolecon.2019.106389

Tao, Y., Duan, M. & Deng, Z., 2021, 'Using an extended theory of planned behaviour to explain willingness towards voluntary carbon offsetting among Chinese consumers', *Ecological Economics* 185, 107068. https://doi.org/10.1016/j.ecolecon.2021.107068

The Conversation, 2021, *COP26 agreed rules on trading carbon emissions – But they're fatally flawed*, viewed from, https://theconversation.com/cop26-agreed-rules-on-trading-carbon-emissions-but-theyre-fatally-flawed-173922.

The Hub, n.d., *Toco*, viewed 12 April 2024, from https://thehub.io/startups/toco.

United Nations, 2024, *'This new finance goal is an insurance policy for humanity': Simon Stiell at close of COP29*, viewed 09 January 2026, from https://unfccc.int/news/this-new-finance-goal-is-an-insurance-policy-for-humanity-simon-stiell-at-close-of-cop29.

United Nations, n.d., *Article 6 of the Paris agreement*, viewed 12 April 2024, from https://unfccc.int/process-and-meetings/the-paris-agreement/article6.

Van der Linden, T. & Shirazi, T., 2023, 'Markets in crypto-assets regulation: Does it provide legal certainty and increase adoption of crypto-assets', *Financial Innovation* 9, 22. https://doi.org/10.1186/s40854-022-00432-8

Venkatesh, V., Morris, M.G., Davis, G.B. & Davis, F.D., 2003, 'User acceptance of information technology: Toward a unified view', *MIS Quarterly* 27(3), 425–478. https://doi.org/10.2307/30036540

Verra, 2025, *Singapore, gold standard, and verra publish article 6.2 crediting protocol*, viewed 12 December 2024, from https://verra.org/singapore-gold-standard-and-verra-publish-article-6-2-crediting-protocol/.

Woo, J., Fatima, R., Kibert, C.J., Newman, R.E., Tian, Y. & Srinivasan, R.S., 2021, 'Applying blockchain technology for building energy performance measurement, reporting, and verification (MRV) and the carbon credit market: A review of the literature', *Building and Environment* 205, 108199. https://doi.org/10.1016/j.buildenv.2021.108199

World Economic Forum, n.d., *Toco – Better money for a better world*, viewed 20 January 2025, from https://weforum.ent.box.com/s/a6qa07fjrhv6bnxk2b2g4olbhggpct0k.

Zheng, X.R. & Lu, Y., 2022, 'Blockchain technology – Recent research and future trend', *Enterprise Information Systems* 16(12), 1939895. https://doi.10.1080/17517575.2021.193989